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TITLE PROGRESS ON A PROTOTYPE MAIN RING RF CAVITY

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PROGRESS ON A PROTOTYPE MAIN RING RF CAVITY*

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A prototype rf cavity and rf drive system for a hadron facility main ring has been designed and will be tested in the Proton Storage Ring (PSR) at Los Alamos as a part of a collaborative effort between LANL and TRIUMF. The cavity uses an orthogonally biased ferrite tuner. The design provides for accelerating gap voltages up to 200 kV for the 49.3 to 50.8 MHz range. Progress on the cavity construction and testing is described.

Introduction

The prototype cavity discussed in this paper is a modified quarter-wave transmission line. The shorted end of the line has been divided into two stubs, as shown in Fig. 1. One of the shorted stubs and the open-circuit end (the accelerating gap) surround the beam line. The other shorted stub includes the ferrite tuner and the coupling capacitor for the rf input. This configuration puts the rf tube to one side of the beam line, which is an advantage if more than one ring is to be put in the tunnel.

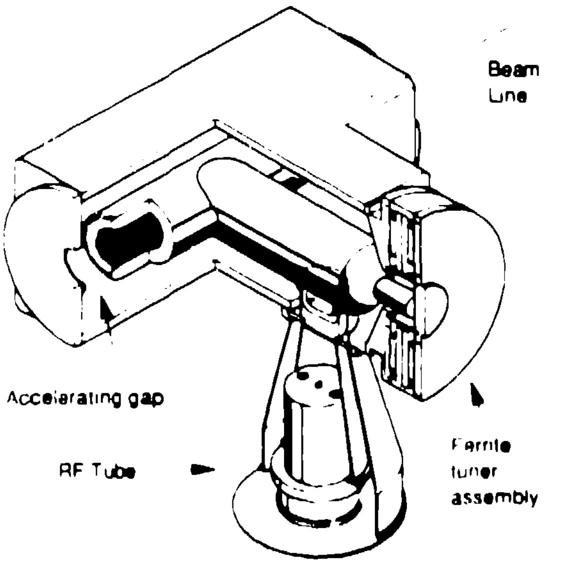

Fig. 1. Cut away isometric view of the prototype main ring rf cavity. (The rf power tube will be mounted above the tuner leg for tests in PSR, not below as shown here.)

The tuner uses two ferrite rings, with the bias coils arranged so that one ferrite ring forms part of the return magnetic path for the other.[1] This configuration reduces the energy stored in the bias magnet by more than a factor of two over previous designs with a corresponding reduction in bias supply power requirements. The bias field in the ferrite is orthogonal to the rf magnetic field, thus producing low rf losses.[2]

Cavity design objectives were 200 kV at the accelerating gap, a tuning range of 3%, a shunt resistance to Q ratio of about 35 ohms, a maximum bias circuit current of 1500 A for the 0.5 inch (1.27 cm) conductors used, and an average power dissipation per unit volume in the ferrite of not more than 1 W/cm^3 over the planned TRIUMF acceleration cycle. The heat dissipated in the ferrite and the resistive power loss in the bias coil are extracted by water flowing in the cooling passages in the bias coil conductors. Additional water cooling is provided for parts of the cavity walls. RF joints are to be reliable enough to permit high-power operation of the cavity even after several disassembly and reassembly operations.

Constraints on the design included shifting the frequency to permit testing in PSR, and using two existing ferrite rings for the tuner. The main ring in the KAON facility planned for TRIUMF is designated the Driver (D) ring. The D ring cavities are tuned from 61.1 to 62.9 MHz as the beam accelerates from 3 to 30 GeV. For test purposes for the prototype cavity, this was scaled to 49.3 to 50.8 MHz, so that the PSR tests could be done at 1/4 of the 201.25 MHz linac frequency, 50.3125 MHz. The ferrite rings were previously used in a prototype booster rf cavity,[3] and are made from Trans-Tech type G-810 aluminum-doped yttrium iron garnet.

Cavity Design

Electrical Design

For analysis purposes, the cavity was represented by a transmission line model. This allowed integration of both ferrite properties and rf cycle information into the calculations.[4] The behavior of the bias field was calculated using the POISSON computer code.[5] It was found that the bias coil turns need to be more closely spaced near the inner and outer radii of the ferrite rings, in order to keep the rf power dissipation in the ferrite from getting too large at those points. The SUPERFISH and MAFIA rf codes were used to model parts of the cavity in order to improve the transmission line model.[6,7] SUPERFISH was used to model the accelerating gap and the end of the tuner leg, including the ferrite regions, a ceramic window and the coaxial transition to the diameters used in the remainder of the cavity. MAFIA was used to model the coaxial T, as that is a 3-dimensional geometry. The bias coil design and other cavity parameters were optimized by looking at the ferrite dissipation results when the transmission line model information was averaged over the TRIUMF acceleration cycle.

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Mechanical Design

The cavity is constructed with a combination of aluminum, copper, and copper-plated stainless steel parts. The outer conductor for the main part of the cavity is a large aluminum casting, as shown in Fig. 2. The rf surface

Fig. 2 An aluminum casting having a length of about 2 m forms the outer conductor for the main part of the cavity. Power from the rf tube will be coupled in through the hole in the top of the tuner leg at the right.

and the joint flange areas on the casting are machined to their final dimensions. Copper tubes for water cooling are swedged into diagonal holes. The inner conductor side of the coupling capacitor and the inner conductor parts are copper-plated stainless steel, except for a short section at the end of the tuner leg, which is aluminum. The power tube side of the coupling capacitor is also aluminum. The inner conductor is cooled by water flowing in its interior or between it and the beam pipe. Cooling water passages are also provided near the rf window at the flange where

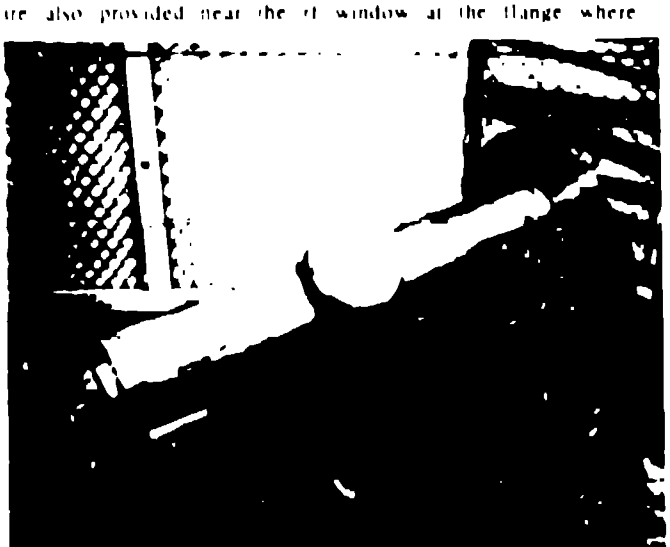


Fig. 3 Inner conductor section for the main cavity. The [illegible]

the short transmission line from the rf power tube connects to the cavity and coupling capacitor. A section of the inner conductor is shown in Fig. 3.

The rf walls on either side of the ferrite rings in the tuner assembly are machined from copper. (See Fig. 4.) Since the turns of the bias coil are generally not closely spaced, these 0.125 inch (0.32 cm) thick walls provide a thermal path which conducts the rf power dissipated in the ferrite and in the surface of the rf walls to the turns of the water-cooled bias coil. The bias coils are insulated with a special epoxy material having a thermal conductivity of 0.03 Cal cm/cm^2 deg C, which is about ten times better than standard epoxy. A chiller will supply cooling water at about 55 deg F (12 deg C), thus providing adaquate cooling capacity at reasonable flow rates. Rubber o-rings press each bias coil towards the adjacent rf wall to maintain good thermal contact. A cylindrical rf window made of alumina separates most of the tuner region from the vacuum region of the main portion of the cavity. This allows the rf walls between the middle bias coils and the ferrite rings to be slotted radially, which permits the high frequency components of the bias field to rapidly penetrate through the [illegible] and into the ferrite.

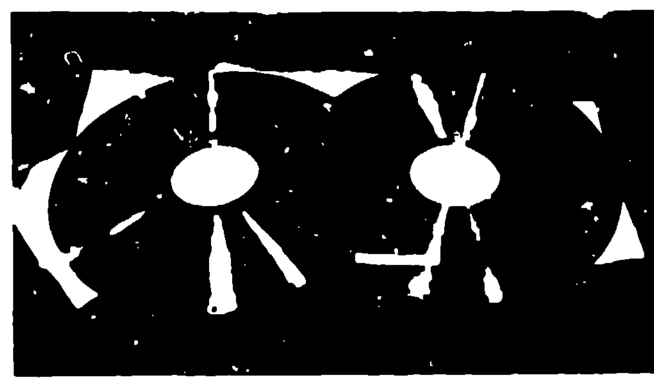
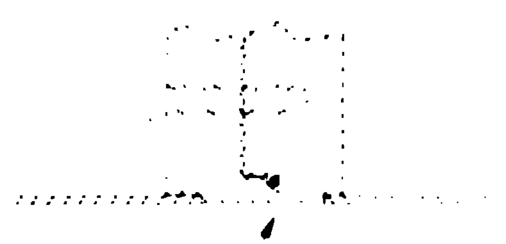


Fig. 4 Copper walls which will be adjacent to the ferrite rings in the tuner part of the cavity.

In a typical demountable rf joint (see Fig. 5), the area of contact is the surface immediately adjacent to the wall carrying the rf current, and the remainder of the joint area is recessed 0.030 inch (0.08 cm). Thus when the connecting hardware is tightened down, pressure is applied at the portion of the joint area where good electrical contact is essential.



RF joint

Fig. 5 A typical demountable [illegible]

Present Status and Plans for Further Work

Tests Without Beam

A test stand for tests without beam is being completed. The anode supply for the rf power tube is in place and has been tested.[8] As of March 1, 1989, the cylindrical rf window for the tuner was on hand, two of the four bias coils had been received from the fabricator, machine work on the outer conductor casting was complete, and machining for the other coaxial and tuner parts was about 75% complete. Some porosity in the outer conductor casting was observed, but did not appear to present a problem. The parts had not been leak checked as of that date. Low-power frequency checks are planned as soon as the machine work on the parts is complete but before the plating is done.

The bias power supply was developed by Byung Han and George Karady,[9] and will be arriving shortly for high-current tests with an inductive load. Measurements to characterize this supply and the cavity will be made in order to permit the design of the tuning control system. The rf phase and amplitude control system has been designed by Ray Burge and coworkers at TRIUMF, and tested using a cavity there. A solid-state driver for the rf power tube has also been built at TRIUMF.[10,11] It is planned to test such a solid-state driver by itself in the PSR tunnel to check its tolerance to radiation. For the initial series of tests, the rf power tube will be an Eimac 4CW150,000E power tetrode. (An Eimac 4CM300,000G power tetrode is also available, but an appropriate input cavity and mounting hardware has not been designed, and most likely would be too large to fit in the PSR tunnel.)

Higher Order Mode (HOM) suppression will be put in after the HOM's have been measured, using suppression techniques being developed on a simplified half-size model of the cavity.[12,13]

Tests With Beam

It is planned to test the cavity and rf system in the PSR in September 1989, just before the end of the operating cycle, or if that is not possible, during a development period sometime next year. Test in a storage ring will not involve beam acceleration, but the effect of beam loading, control system transient response to empty buckets, and the effect of the cavity on beam stability will be studied.

References

[1] W. R. Smythe, "A Proposed New Cavity Configuration," record of Ferrite Tuned RF Working Group Meeting, Los Alamos National Laboratory, September 3, 1987.

[2] W. R. Smythe, T. G. Brophy, R. D. Carlini, C. C. Friedrichs, D. L. Grisham, G. Spalek, and L. C. Wilkerson, "RF Cavities with Transversely Biased Ferrite Tuning," IEEE Trans. Nuclear Science, Vol. NS-32, No. 5, 2951-2953 (October 1985).

[3] C. C. Friedrichs, R. D. Carlini, G. Spalek, and W. R. Smythe, "Test Results of the Los Alamos Ferrite Tuned Cavity," Proc. 1987 IEEE Particle Accelerator Conf., Washington D.C., March 16-19, 1987 (IEEE, New York, 1987), Vol. 3, pp. 1896-1897.

[4] G. R. Swain, "Design of a Main Ring Cavity," Proceedings of the Advanced Hadron Facility Accelerator Design Workshop, Los Alamos, Feb. 22-27, 1988, Los Alamos National Laboratory report LA-11432-C, Jan. 1989, pp. 365-380.

[5] M. T. Menzel, and H. K. Stokes, "User's Guide for the POISSON/SUPERFISH Group of Codes," LA-UR-87-115, Los Alamos Accelerator Code Group, MS H829, Los Alamos National Laboratory, Los Alamos, NM 87545 (January 1987).

[6] G. R. Swain, "Main Ring RF Cavity," Proceedings of the 1988 Summer Study on High Energy Physics in the 1990's, Snowmass, Colorado, June 27 - July 15, 1988.

[7] G. R. Swain, "Improvements to a Transmission Line Model of a Main-Ring Cavity," presented at the Accelerator Design Workshop, Los Alamos, Feb. 20-25, 1989.

[8] C. C. Friedrichs, "AHF RF Test Stand Anode Power Supply," presented at the Accelerator Design Workshop, Los Alamos, Feb. 20-25, 1989.

[9] B. M. Han, "Design of a Tuning Magnet Power Supply for the KAON Accelerator," MS thesis, Arizona State University, Dec. 1988.

[10] R. L. Poirier, "Status of RF Development Program at TRIUMF," Proceedings of the Advanced Hadron Facility Accelerator Design Workshop, Los Alamos, Feb. 22-27, 1988, Los Alamos National Laboratory report LA-11432-C, Jan. 1989, pp. 342-349.

[11] S. Kwiatkowski, T. Enegren, and R. L. Poirier, "Design of The 150 kW 46-62 MHz Power Amplifier for the TRIUMF Kaon Factory Booster Ring," Proceedings of the European Particle Accelerator Conference, Rome, Italy, June 6-11, 1988.

[12] L. Walling, "Damping Higher Order Modes in an AHF Main Ring Cavity," presented at the Accelerator Design Workshop, Los Alamos, Feb. 20-25, 1989.

[13] J. Griffin, et al., "Higher Order Mode Damping in Kaon Factory RF Cavities," elsewhere in these proceedings.